VERDIGRIS RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body: Eureka City Lake
Water Quality Impairment: Eutrophication bundled with Siltation

Subbasin: Upper Verdigris **County:** Greenwood

HUC 8: 11070101 **HUC 10** (HUC 12)**:** **03** (03)

Ecoregion: Flint Hills

Drainage Area: 15.4 square miles in Bachelor Creek Watershed

Conservation Pool: Area = 238 acres, Maximum Depth = 9 meters

Designated Uses: Primary Contact Recreation (A); Expected Aquatic Life Support; Domestic Water Supply; Food Procurement; Industrial Water Supply; Irrigation Use; Livestock Watering,

303(d) Listings 2004 Verdigris Basin Lakes, Eutrophication; 2008 Verdigris Basin Lakes, Eutrophication and Siltation

Impaired Use: Primary Contact Recreation and Domestic Supply uses are impaired/threatened

Water Quality Standard: Nutrients - Narrative: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life. (KAR 28-16-28e(c)(2)(B)).

Suspended Solids – Narrative: Suspended solids added to surface waters by artificial sources shall not interfere with the behavior, reproduction, physical habitat or other factor related to the survival and propagation of aquatic or semi-aquatic or terrestrial wildlife. (KAR 28-16-28e(c)(2)(D)).

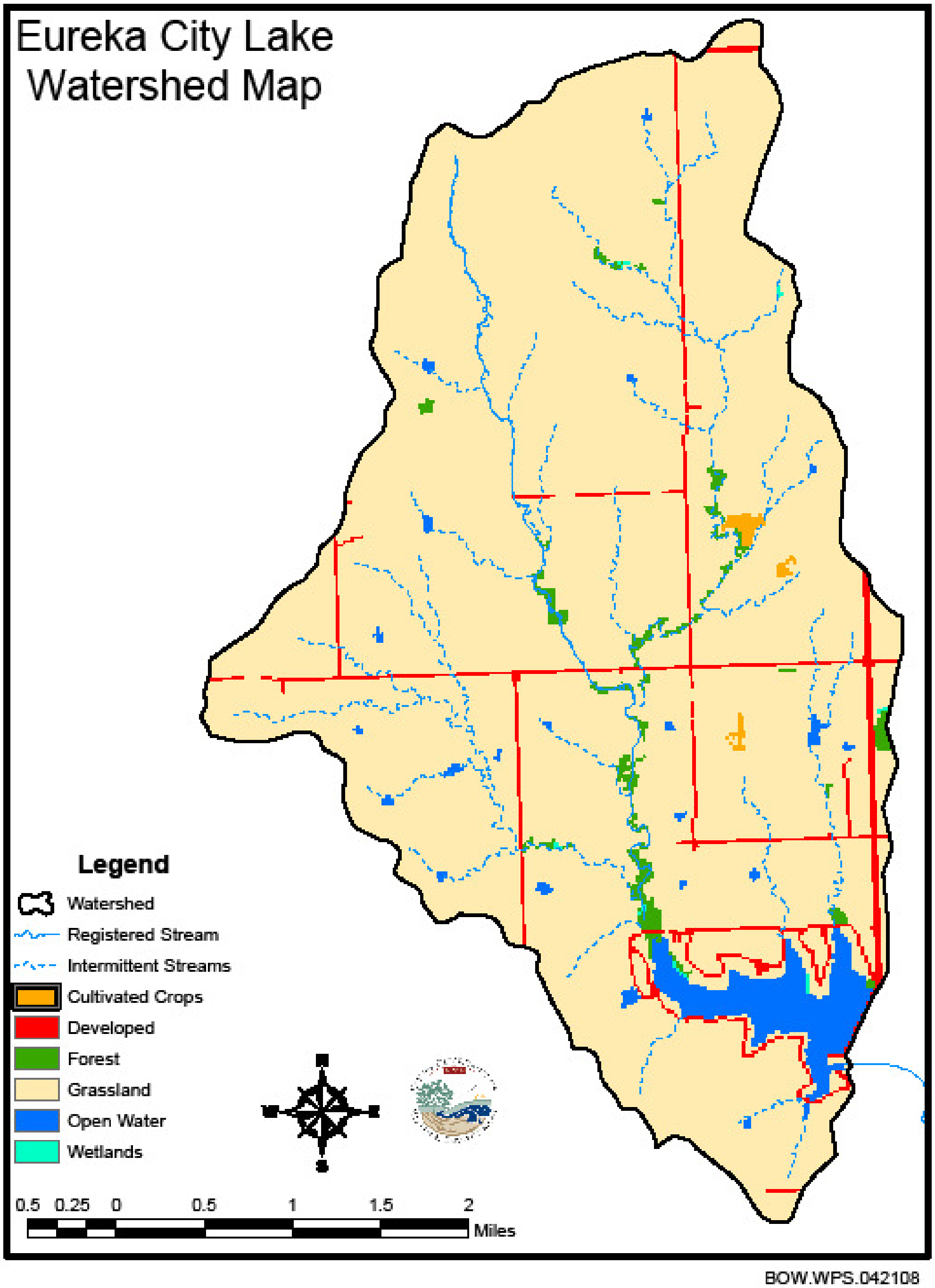

Figure 1- Land uses in the Eureka City Lake watershed. Bachelor Creek and Eureka City Lake are the only waters in this watershed on the Kansas Surface Water Register.

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Dam Closure: 1939

Monitoring Sites: Station LM040201in Eureka City Lake. (Figure 1), as with most small reservoirs, no upstream gage, or ongoing measure of inflow and precipitation is available for this waterbody.

Period of Record Used: Six surveys from 1985 to 2005.

Current Condition: During the monitoring period the lake has typically more than 7 mg/L dissolved oxygen in the top 3 meters of the water column (Figure 2), and surface pH has averaged 7.95. Chlorophyll A has been highly variable, with an average chlorophyll A at the surface has been 17.8 ppb. Secchi depth has averaged 0.84 m, and ranged from 0.7 to 1.01 meters (Figure 3). TSS has averaged 9.2 mg/L, below current KDHE reporting limits. Epilimnetic total nitrogen has averaged 0.535 mg/L (Figure 4) and epilimnetic total phosphorus has averaged 0.038 mg/L (Figure 5). PRISM data indicates that a long-term average rainfall of 35" per year, and USGS estimates of mean flow (Perry et al., 2004) average annual flow of Bachelor Creek above Eureka City Lake at 10.5 cubic feet per second (cfs). Flow duration percentiles estimated in Perry et al. are 0, 0, .86, 3.56, and 11.7 cfs at 90, 75, 50, 25, and 10th percent exceedences. An alternative USGS lake data source provides estimates of for this area indicate a mean annual flow of 6.7 cubic feet per second and annual average evaporation rate of 53.5".

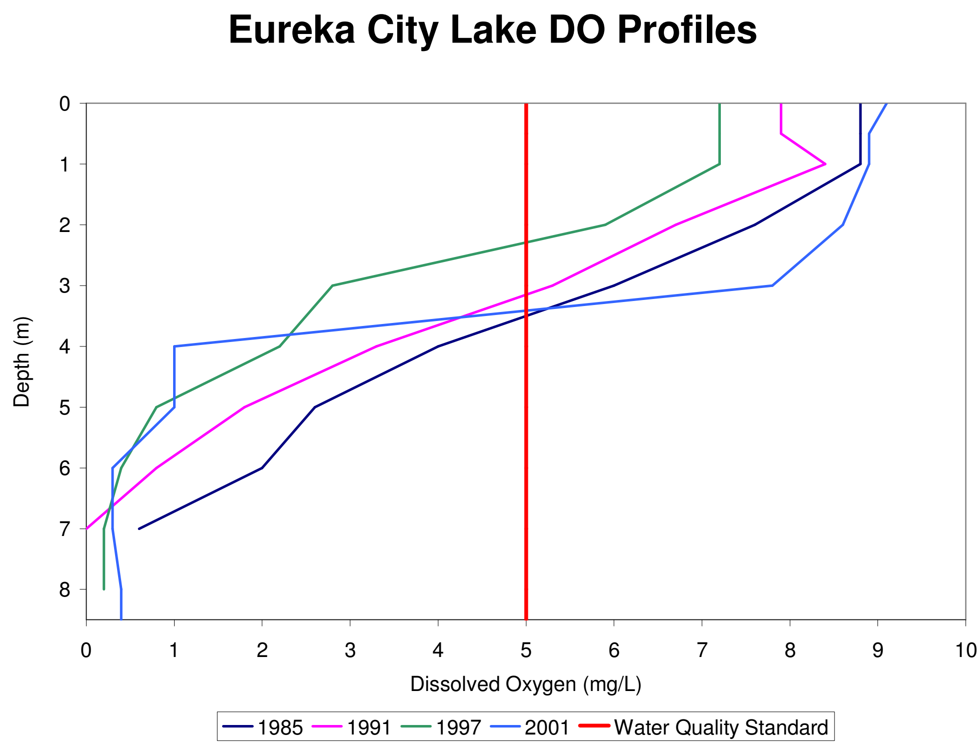

Figure 2- Dissolved oxygen profiles for the four whole column sampling events from 1985-2001. In 1989 and 2005 low water levels prevented boat access, so no dissolved oxygen profiles were conducted.

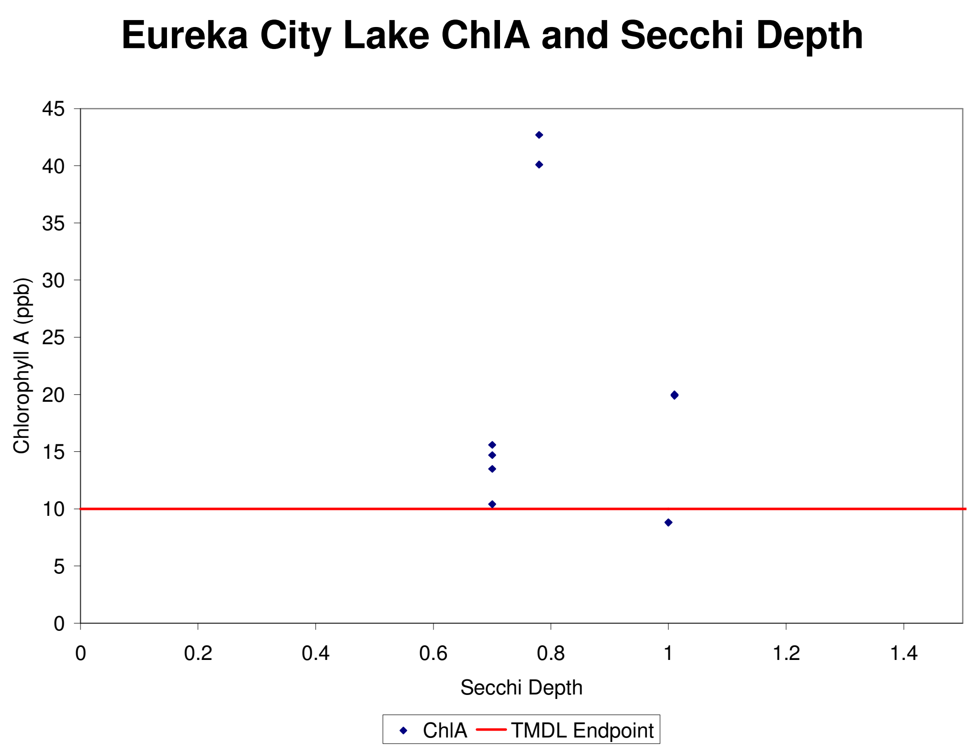

Figure 3- Secchi depth and chlorophyll A concentrations do not appear to be linked in this water body at the present time.

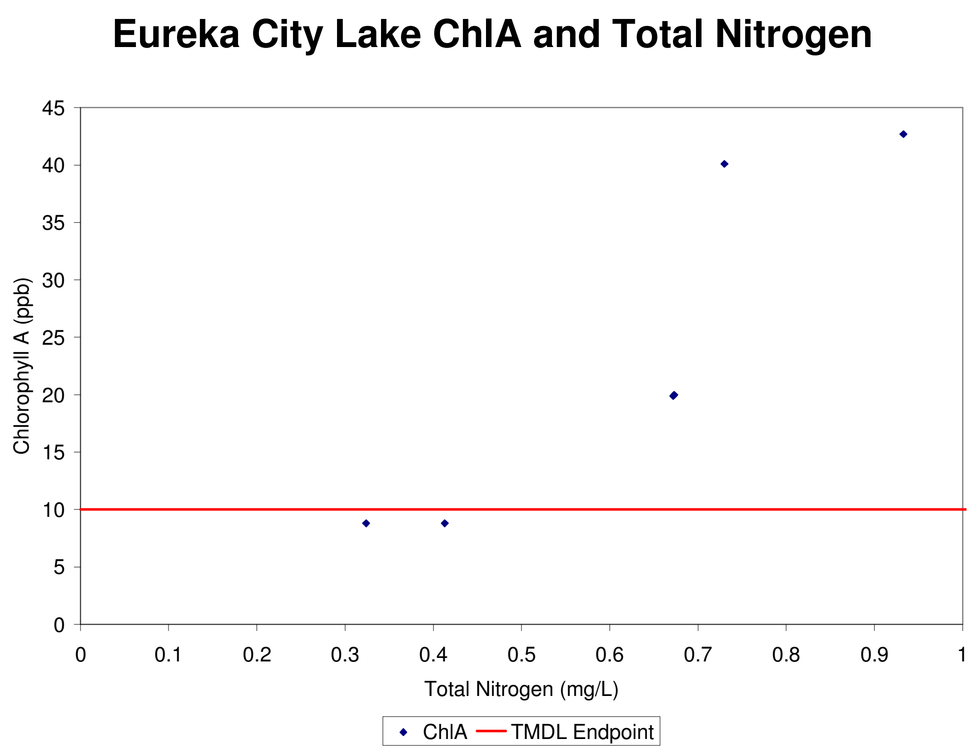

Figure 4- Chlorphyll A concentrations in Eureka City Lake as a function of the total nitrogen concentrations during time of collection.

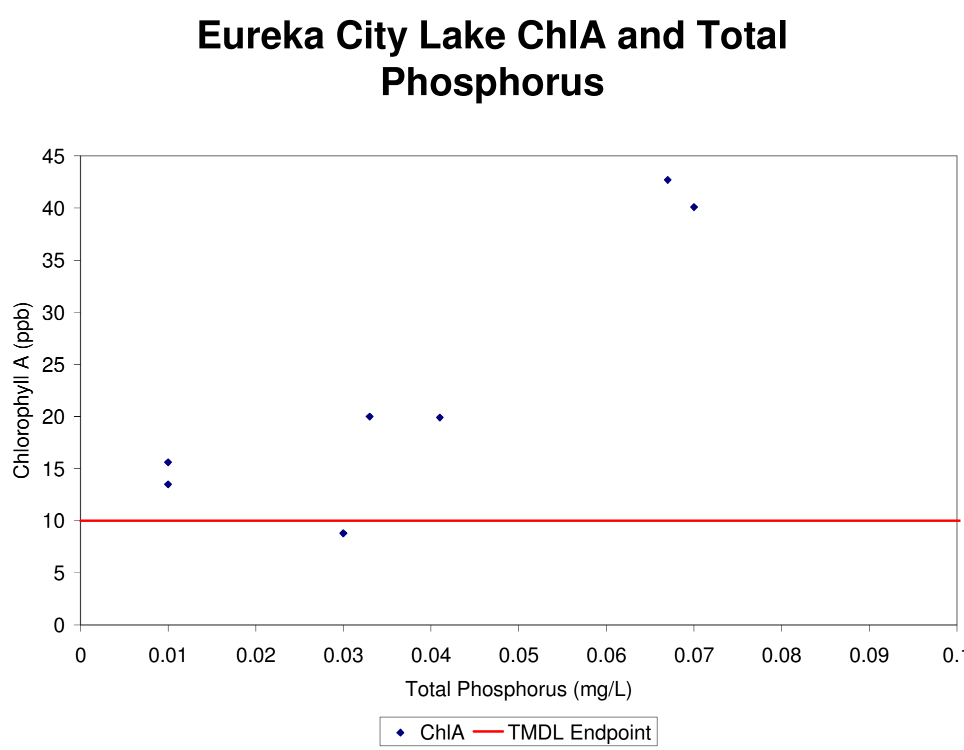

Figure 5- Chlorophyll A concentrations in Eureka City Lake as a function of total phosphorus concentration at time of collection.

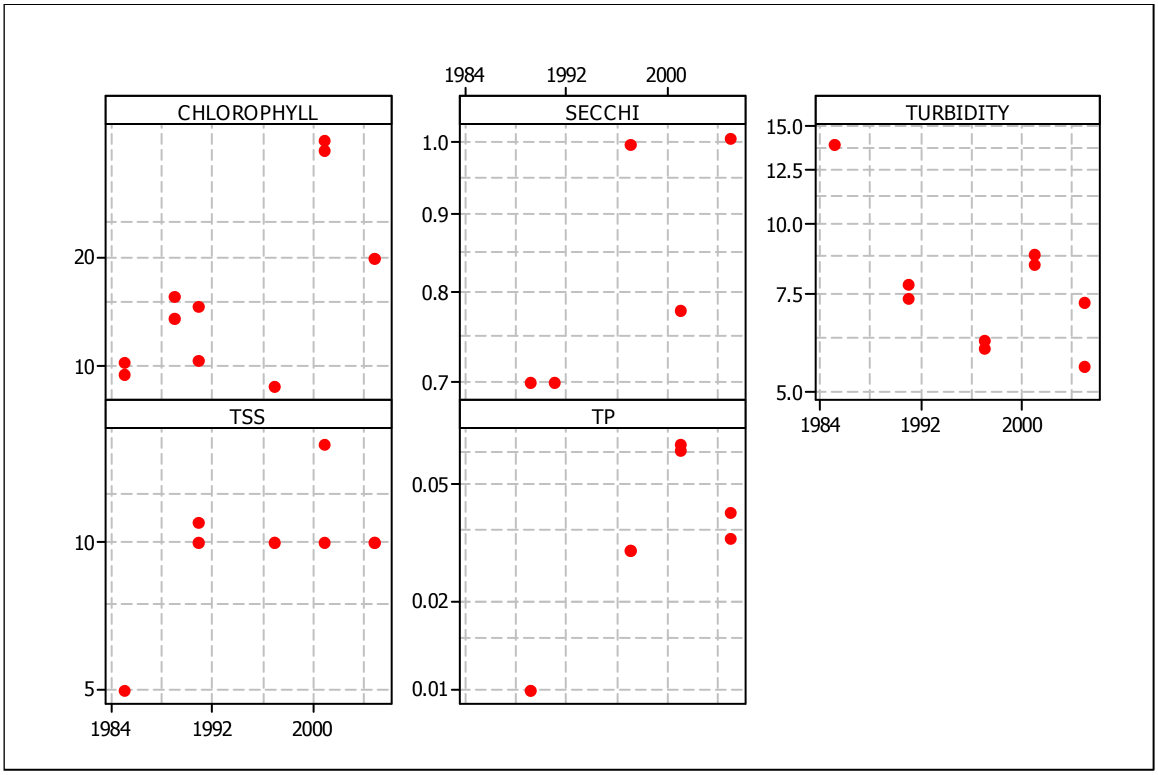

Figure 6- Miscellaneous epilimnetic water quality parameters over time in Eureka City Lake.

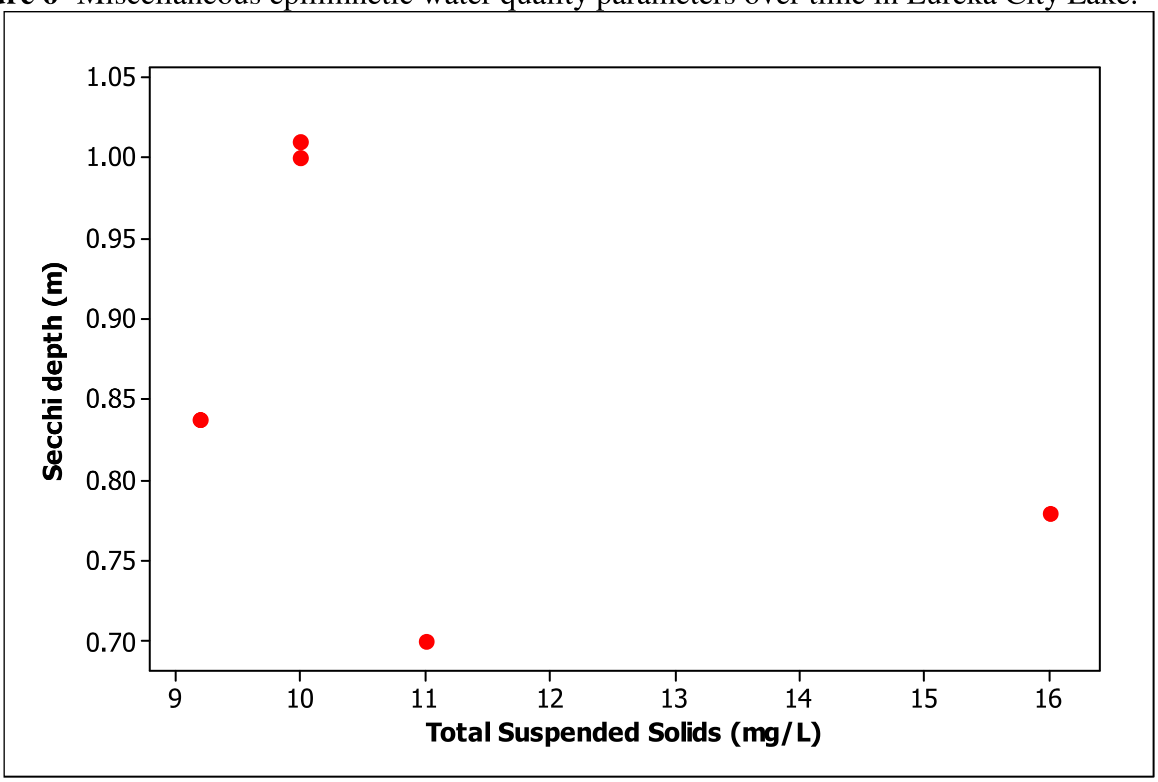

Figure 7- Secchi depth in Eureka City Lake as a function of total suspended solids.

Sample Date	Chlorophyll A (ppb)	TN (mg/L)	TP (mg/L)	Secchi Depth (m)	Turbidity (NTU)	TSS (mg/L)
7/1/1985	9.83	N/A	N/A	N/A	14.00	5.00
6/20/1989	14.55	N/A	0.01	0.70	N/A	N/A
8/27/1991	12.55	N/A	N/A	0.70	7.60	10.50
6/9/1997	8.80	0.37	0.03	1.00	6.10	10.00
6/25/2001	41.40	0.83	0.07	0.78	8.70	13.00
7/25/2005	19.25	0.63	0.04	1.01	6.42	9.73

Table 1- Table of average epilimnetic water quality data for major parameters as monitored by KDHE at Eureka City Lake. Fields marked N/A were not measured.

Interim Endpoints of Water Quality (Implied Load Capacity) at Eureka City Lake over 2008 - 2015: This TMDL shall serve primarily as a protection measure to ensure that the threatened uses are protected and that the lake will continue to serve its designated uses. Therefore, the interim endpoint shall be reflective of primary contact recreation and drinking water supply uses and is chlorophyll a less than 10 ppb. For siltation a protection TMDL standard shall apply to ensure that this lake preserves its potential for public water supply and will be at least 50% of the lake area with 10' or greater in depth in 2016. To support continuous recreation use, concurrent with preservation of storage capacity, the lake average depth near shorelines should not decrease by less than 0.5 feet by 2016.

3. SOURCE INVENTORY AND ASSESSMENT

Land Use: Land use in this watershed is predominantly permanent grassland, with minimal localized areas of row crop production (Figure 1, Table 1). Riparian zones along perennial streams are largely buffered by permanent vegetation.

Major Land Uses	Acres	Sq. Miles	Percent of Watershed
Grassland	9058	14.15	91.85%
Open Water	315	0.49	3.19%
Developed	313	0.49	3.18%
Forest	140	0.22	1.42%
Cultivated Crops	27	0.04	0.28%

Table 2- Land use in the Eureka City Lake watershed extracted from the 2001 National Land Cover Dataset.

The Kansas Biological Survey (KBS) conducted a bathymetric survey of Eureka City Lake in late 2007 (Figure 6), 3,034 individual depth points were collected. Data from this survey and a digitized upper boundary of the lake drawn from the National Agricultural Imaging Program (NAIP) 2004 photographs (Figure 7) were combined in a single point file. Boundary points were assigned an elevation of conservation pool (1,158' above sea level). The point file was converted into a triangulated irregular network (TIN) to represent the current bottom surface of the lake (Figure 8).

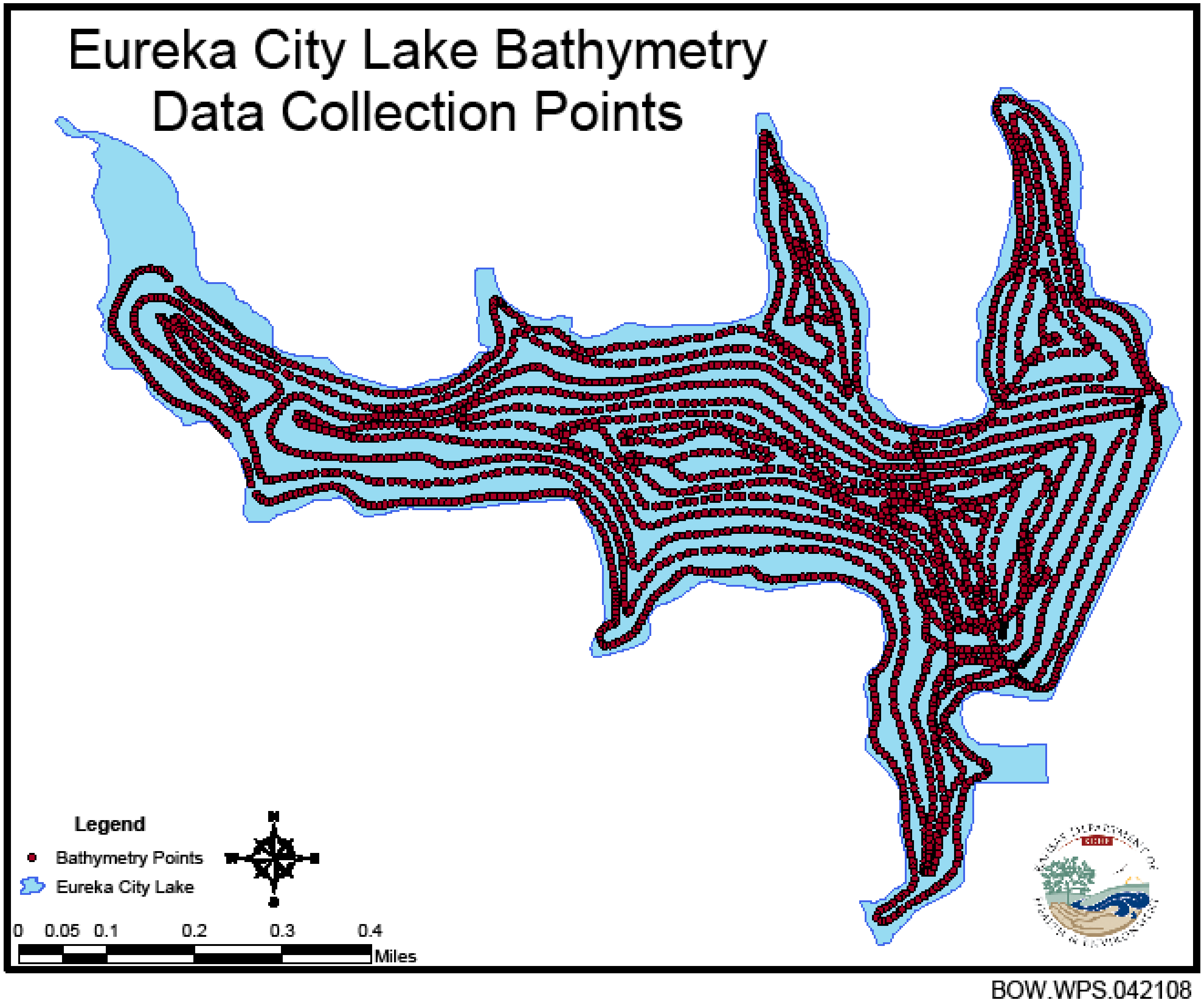

Figure 8- Bathymetry data collection points from Kansas Biological Survey. 3,034 individual points are shown.

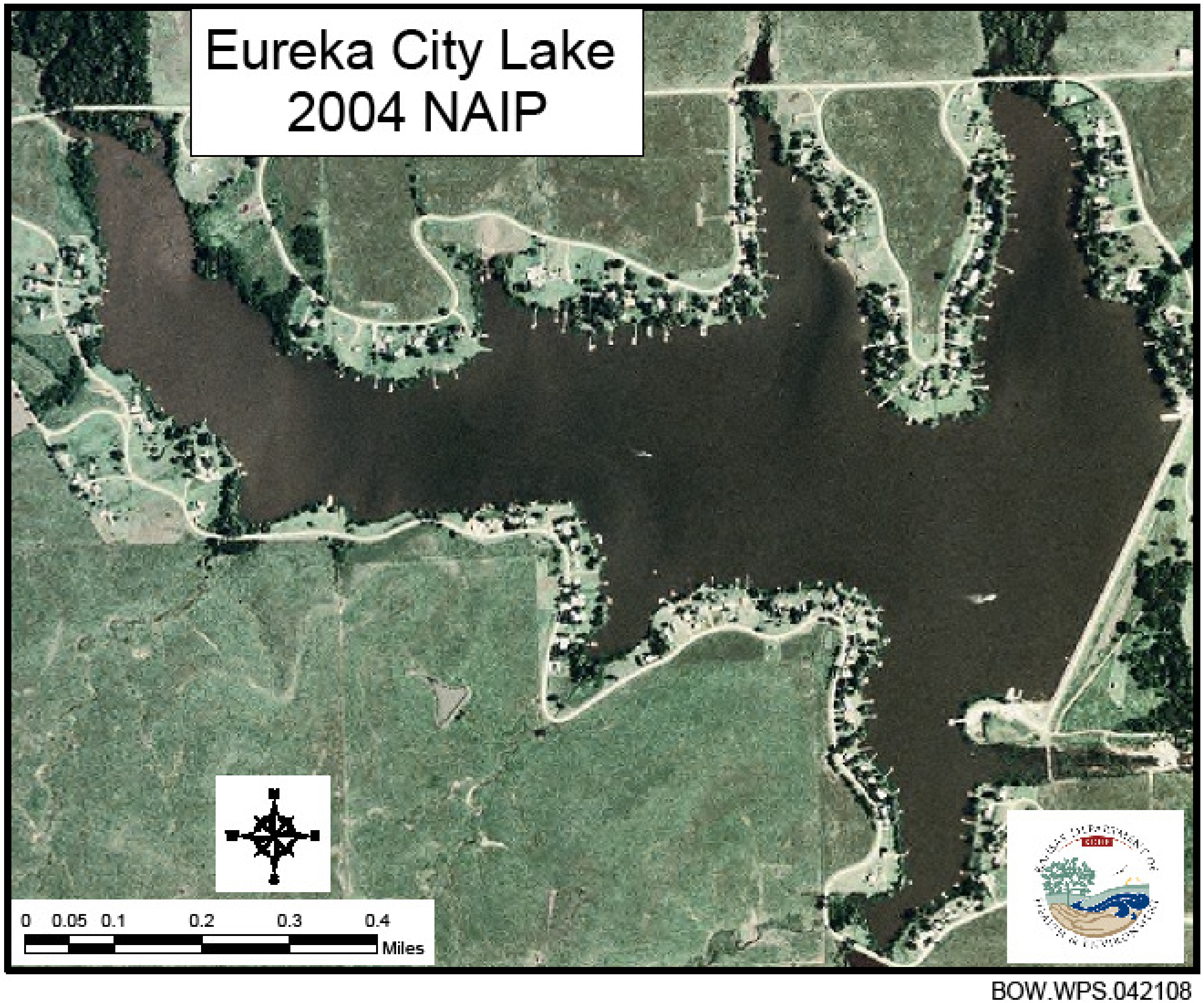

Figure 9- National Agricultural Imaging Program (NAIP) 2004 aerial photographs of Eureka City Lake

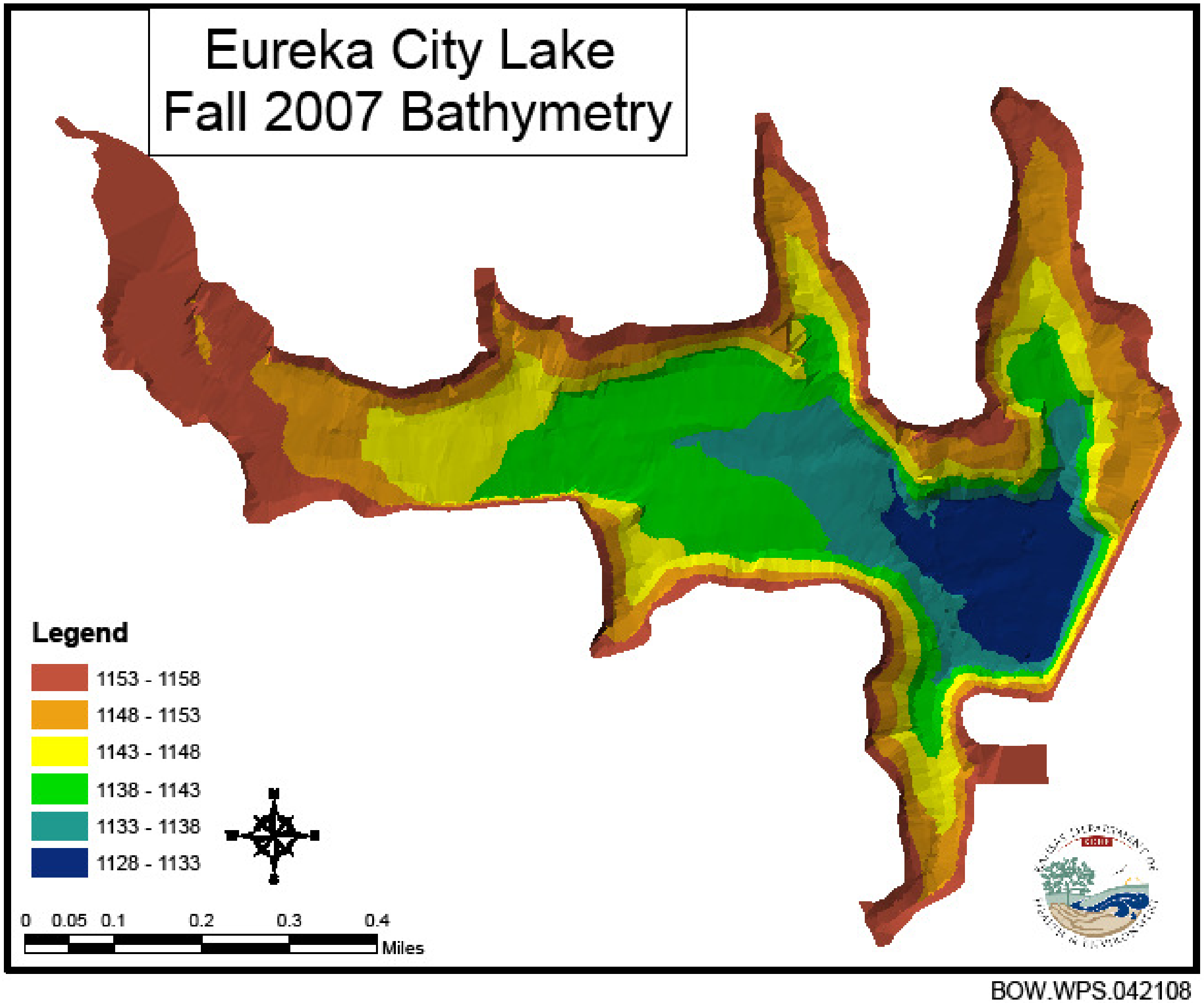

Figure 10- A triangulated irregular network (TIN) of the elevation above sea-level in feet of the bottom of Eureka City Lake.

While no data regarding the original design capacity of the lake was available, an estimate of annual sediment and nutrient load can be made by comparing to other measured rates at lakes in the area with similar land use patterns. Fall River Lake was recently assessed (Jurasek, 2008) using sediment coring and bathymetry, and estimated a mean annual net sediment yield of 0.46 tons per acre per year (0.34 acre feet per square mile per year), 1.82 lbs total nitrogen per acre per year, and 0.75 lbs total phosphorus per acre per year. Translated to the Eureka City Lake watershed, these values estimate a mean annual load of 4,540 tons of sediment (5.2 acre feet), 17,961 lbs of total nitrogen, and 7,401 lbs of total phosphorus per year. Comparison of total phosphorus results with other data used in this analysis determined that this number is likely a significant overestimate, and should be adjusted by watershed size before use in further calculations. Back calculation yields an estimate of 354 acre feet of lost storage capacity since closure. The sediment results are similar to results obtained for Winfield City Lake, which shares similar land use and climate patterns, and was also bathymetrically profiled in 2007.

The KBS survey data shows that the lake has a current capacity at conservation pool of 2,924 acre feet of water (Table 2). Surface area is 238 acres, and the average depth is 11.89’. Adding the estimated sediment load since closure to current capacity generates a pre-impoundment capacity estimated at 3,278 acre feet of water at conservation pool. While we calculate an average annual storage loss of 5.2 acre feet capacity in Eureka City Lake each year, it’s likely that most of the load arrives during a few large storm events that are unevenly distributed through the years. At this rate Eureka City Lake will be completely full in 563 years, or around 2570 A.D (Figure 9).

	Volume (acre feet)	Surface area (acres)	Avg. Depth (feet)
Current	2,924	238	11.89
Pre-impoundment	3,278	238	Unknown
Change	354	0.0	Unknown

Table 3- Summary capacity data for Eureka City Lake before the dam was constructed and currently.

Depth Range	Acres with specified depth	Percent of Lake Area
0-5 feet	56	24%
5-10 feet	51	21%
10-15 feet	40	17%
15-20 feet	49	20%
20-25 feet	23	10%
>25 feet	19	8%

Table 4- Percent of lake surface area with specified depth zones.

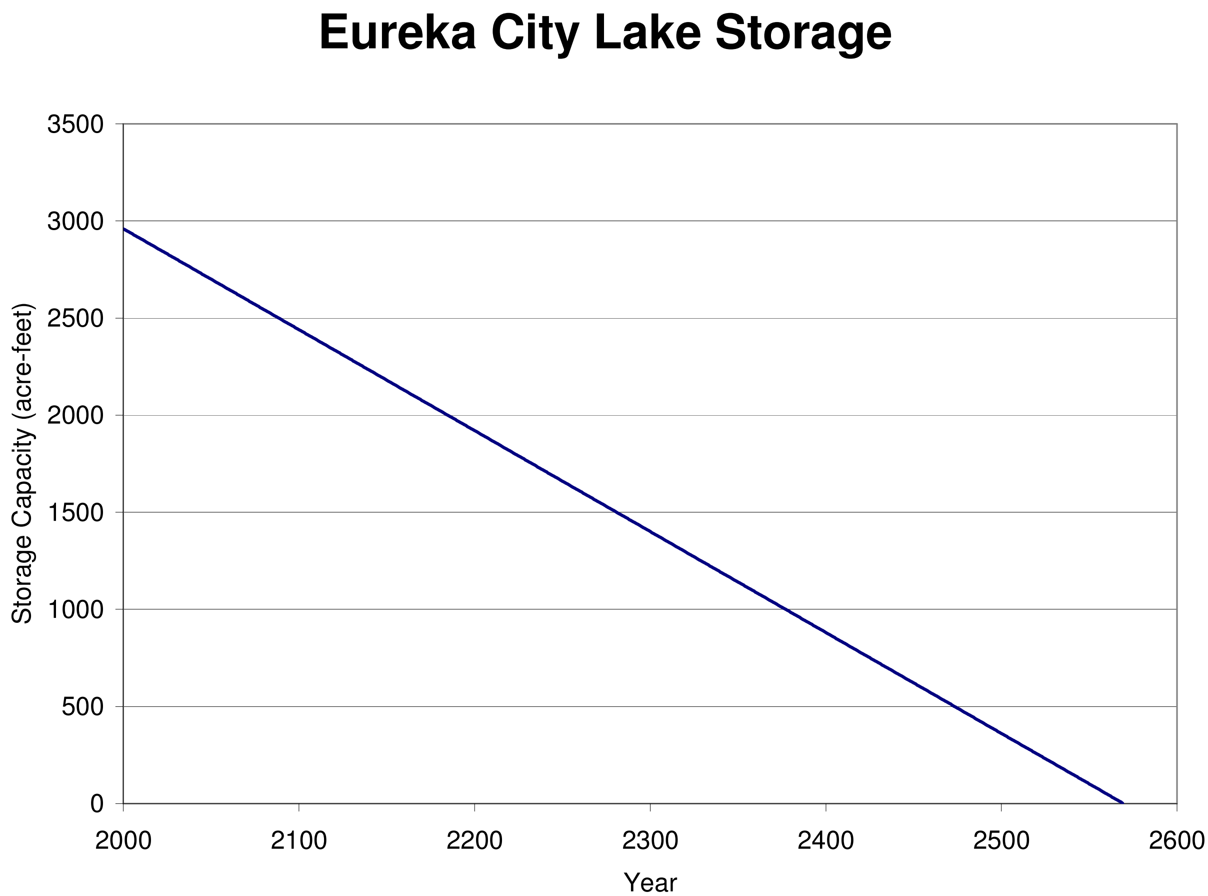

Figure 11- A linear approximation of projected storage by year assuming current rates of sedimentation continue. This waterbody is estimated to have 563 years until the entire conservation pool is filled with sediment. Useful storage life as a water supply reservoir is likely to be much shorter.

There may be a delta forming at the outlet of Bachelor Creek into Eureka City Lake at the western most end. 2002 Digital Orthoquad (DOQQ) photographs were taken during a dry period, and show some possibility of mud flats are forming in these upper reaches (Figure 10). No maps could be made of the areas of deposition since closure, however current depth maps (Figure 11) will provide a base-line should future surveys be conducted, that will allow adjustments to loading estimates.

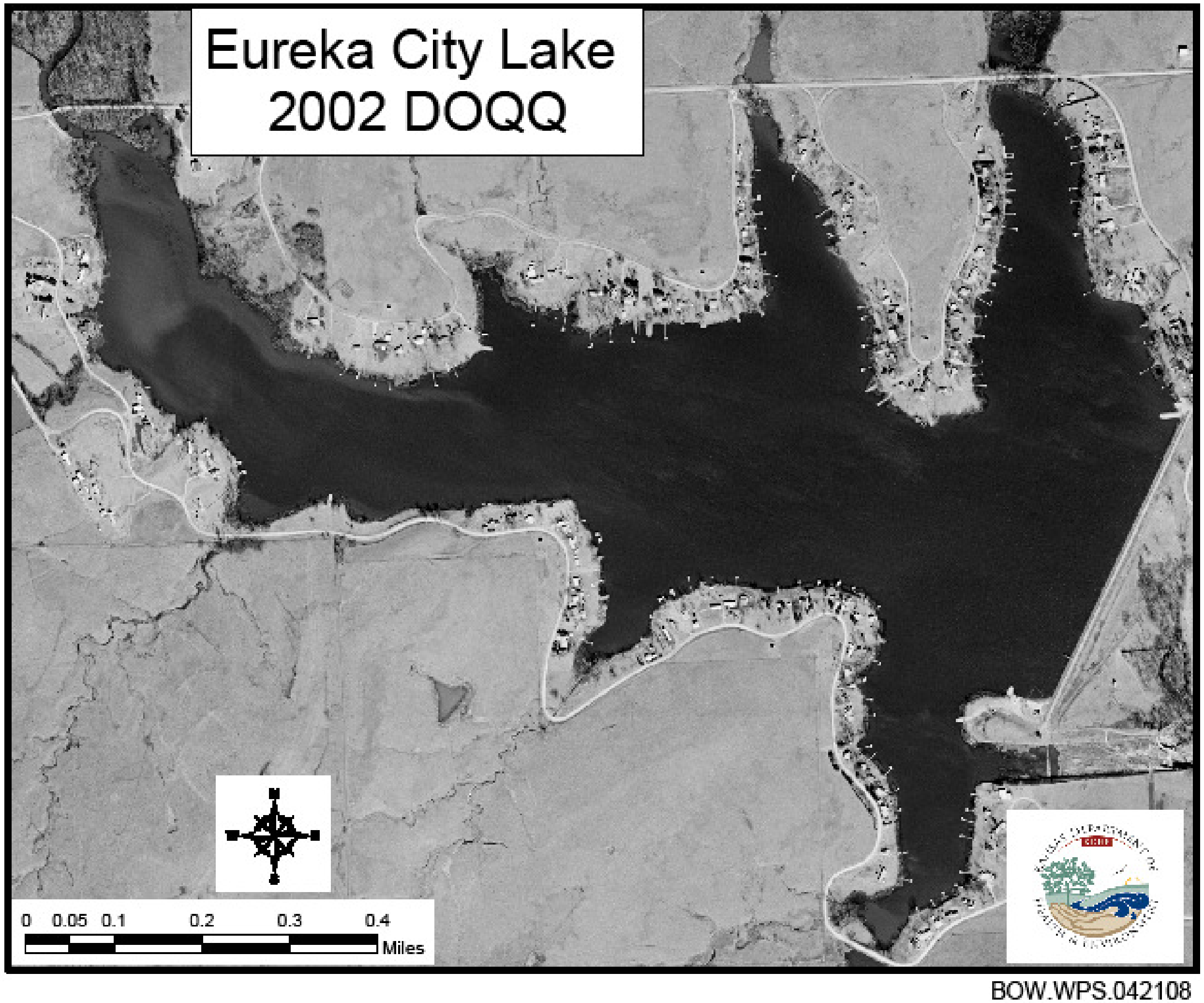

Figure 10- 1 meter resolution aerial photographs of Eureka City Lake taken during a low water period. Visible in the upper end of the lake is a small delta forming from deposited sediment.

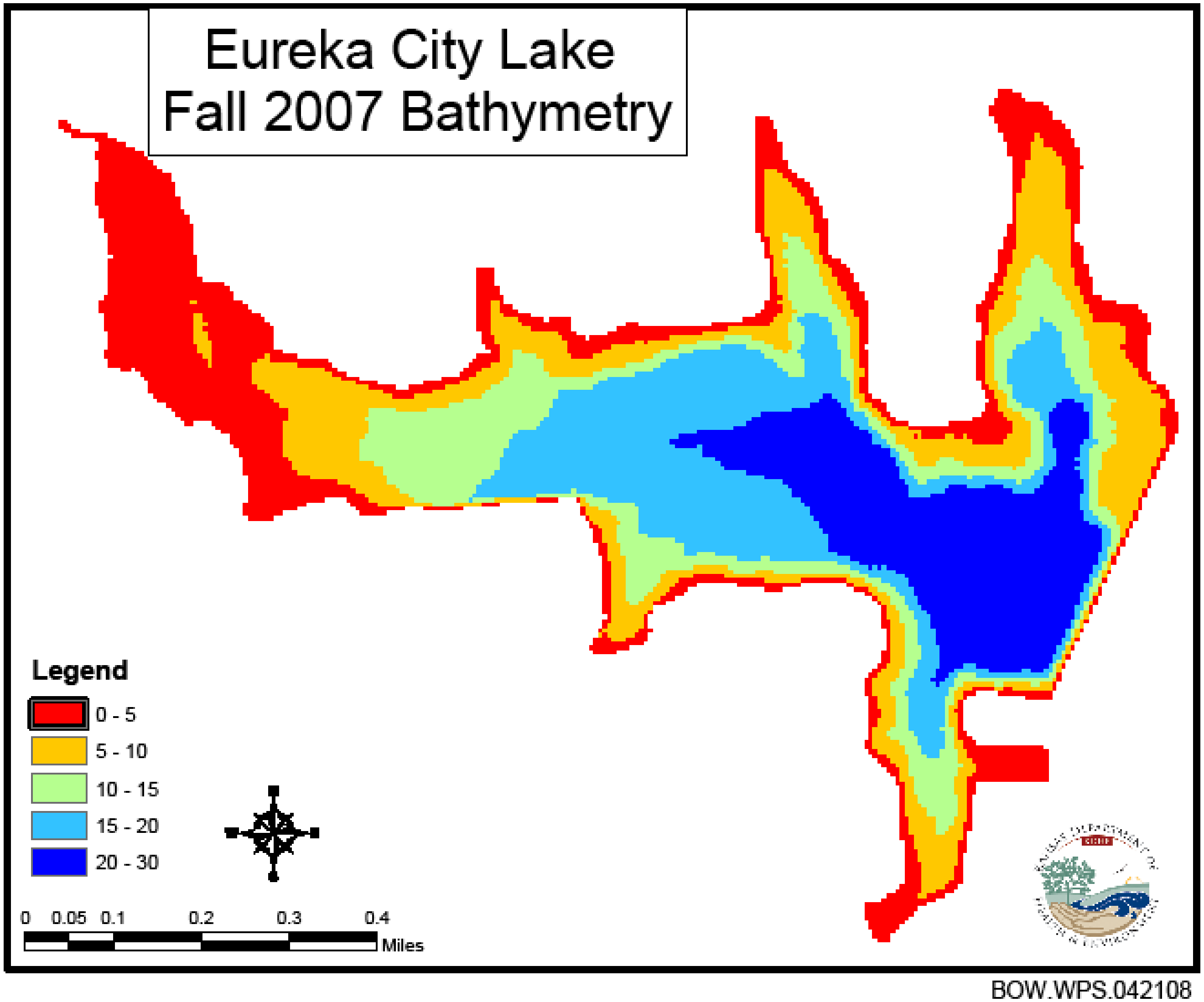

Figure 11- Depth in feet from the top of conservation pool.

A BATHTUB model was used to estimate phosphorus and nitrogen loadings to Eureka City Lake. A single segment model was selected due to the small size of the lake. Two tributary inputs were used in the model, one for watershed source loading and the other for failing septic systems. Details of the model calibration and data sources are provided in Appendix D. Model case data and output of mass balance and water quality parameters are provided in Appendix A. A STEPL model was developed to compare net watershed loading estimates from the BATHTUB model. STEPL results and data are included in Appendix E.

After calibration, the BATHTUB model estimated that the average load of total phosphorus entering the lake is currently 872 lbs/year and the average load of total nitrogen is 19,753 lbs/year (Table 5). This level of loading corresponds to the average chlorophyll concentration of 17.8 ppb. A reduction of the average chlorophyll concentration to less than 10 ppb is expected to assure attainment of water supply uses. The calibrated model was used to determine the needed nutrient reduction that would correspond to less than 10 ppb chlorophyll concentrations. A reduction of watershed total phosphorus loading to 396 lbs/year, amounting to a reduction of total phosphorus load by 476 lb/s year (54%) and a reduction of watershed total nitrogen to 8,256 lbs per year, amounting to a reduction of total nitrogen by 11,497 lbs/year (58%), is predicted to provide adequate water quality. Further reductions beyond this level will likely lead to even better conditions in the lake. Load allocations are shown in Table 6. The watershed source loading estimates generally correspond to those produced in the STEPL model, with some divergence noted in the estimates of failing septic system contributions.

Internal Loading: Due to inadequate local data on the potential for internal nutrient load, no estimates of internal loading were made. Internal loading is a complex function of hydrologic conditions, lake morphometry, and lake sediment nutrient availability. Should internal loading allow non-marginal quantities of nutrient supply to the photosynthetic organisms in the lake, model revisions would need to be made.

Other Sources: No permitted dischargers or non-discharging permitted facilities exist within the watershed. No permitted confined animal feeding operations exist within the watershed. Some nutrient flux may originate with livestock on range with access to surface waters in the watershed, which should be accounted for in the watershed load. Some shoreline erosion may occur in the main pool of Eureka City Lake. These source are likely small overall contributors to the observed concentrations in this waterbody.

2000 Census data indicated that as many as 126 people live in the watershed. Of these, 71 reside adjacent to the lake, where they are likely served by on-site wastewater systems. There are a total of 123 lakeside houses, as determined through the use of 2002 aerial imagery (DOQQ). The disparity between census population and house numbers suggests most of the lake residences are used on a seasonal or temporary basis, and are not primary residences. If these systems are failing, their proximity to the lake could make them a contributor to the observed water quality in Eureka City Lake. Estimates of seasonal use patterns are included in Appendix D.

An estimate of the contribution from failing septic systems was made by inclusion of a septic system "tributary" in the BATHTUB model. Details of the source data and estimated parameters used in the BATHTUB model are included in Appendix D. Better data regarding the prevalence of failing on-site systems and system use level (number of people per house, number of days of occupancy each year, etc.) would allow improvement in calculating the actual load from this source.

Use of lawn fertilizer at lakeshore residences may also contribute nutrients to the lake. Near lake erosion from sources such as dirt roads and other bare surfaces may also contribute to sediment loading in this lake.

Source	TP Load (lbs/yr)	TN Load (lbs/yr)	Sediment (lbs/yr)
Watershed	743	17,966	9,080,000
Septic Systems	107	375	N/A
Precipitation	21	1,412	N/A
Total	871	19,753	9,080,000

Table 5- Modeled annual load estimates from each source of nutrients and sediment.

Background Levels- Some of the land in the watershed is woodland; leaf litter may be contributing to the nutrient loading. The nutrient recycling, atmospheric deposition, and geological formations (i.e., soil and bedrock) may contribute to phosphorus and nitrogen loads.

Critical Conditions/Seasonality- Because eutrophication related impairments to drinking water supply uses are most likely to occur during summer months due to warmer temperatures and greater photosynthetically available radiation, summer monitoring will continue. Other seasons are not critical to the eutrophication related issues in this reservoir. Siltation related impairments are most likely to be aggravated during spring and summer months due to the increased available rainfall and increased anthropogenic and livestock related activity in the watershed.

Uncertainty- Modeling data was selected from best available regional data sources, actual measured lake conditions from KDHE sampling, and best-professional judgment regarding patterns of use at lakeshore residences. No actual measure of the number of failing septic systems was made, nor were local surveys done to determine actual use patterns. Water quality parameters on tributaries were estimated, and may diverge from actual concentrations. No upstream gage data is available for this lake, nor are daily estimates of inflow. This model does not account for the potential impacts of internal nutrient loading. Stocking densities were estimated based on county level data, and may vary locally from those rates estimated here. Estimates of per/acre annualized soil loss were based on rates measured in other nearby lakes, however local conditions may vary from those measured elsewhere. Original volume estimates were unavailable, requiring back calculation assuming constant volume loss.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Phosphorus and nitrogen co-limit the primary production in Eureka City Lake and are allocated under this TMDL. Sediment, as measured by lost capacity, is also allocated to address siltation. The general inventory of sources within the drainage provides guidance as to areas of load reduction. The lack of upstream monitoring, particularly during runoff events, limits our ability to verify model results. As more information regarding individual source contributions become available the relative proportions of reductions may be modified to most accurately address contributions to the water quality in this lake.

Point Sources: A current Wasteload Allocation of zero is established by this TMDL because of the lack of point sources in the watershed. Should future point sources be proposed in the watershed and discharge into the impaired segments, the current Wasteload allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers.

Nonpoint Sources: Water quality violations are predominantly due to nonpoint source pollutants. Reduction of total phosphorus concentrations less than 20 ppb and total nitrogen concentrations to less than 334 ppb in the lake should protect water quality and maintain the designated uses. To reduce total phosphorus concentrations to this level will require a reduction of loading by 436 lbs/yr including the defined margin of safety. To reduce total nitrogen concentrations to this level will require a reduction of loadings by 12,323 lbs/yr including the defined margin of safety. No allocation is made in the reduced model for failing septic systems, as these sources of impairment should be eliminated entirely.

Siltation protection shall be provided by maintaining sedimentation at or below currently observed levels of 5.2 acre-feet per year. This level of siltation will result in loss of less than 0.5' within the areas currently less than 10' in depth by 2016 (8 years * 5.2 acre-feet/107 acres=0.388' depth loss). This storage loss is equivalent to 9,080,000 lbs of sediment per year including the defined margin of safety (conversion factor: 1,746,000 lbs/acre foot; Juracek, 2008).

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus loading. The margin of safety will be to provide capacity for 10% more potential phosphorus and nitrogen than is seen in average annual loads, or 40 pounds of total phosphorus per year and 826 pounds of total nitrogen per year. The sediment defined margin of safety is 908,000 pounds per year.

Load Allocations	TP (lbs/yr)	TN (lbs/yr)	Sediment (lbs/yr)	TP (lbs/day)	TN (lbs/day)	Sediment (lbs/day)
Waste Load Allocation	0	0	0	0.00	0.00	0
Atmospheric Deposition	21	1,412	0	0.15	10.38	0
Load Allocation	356	7,430	8,172,000	2.61	53.59	60,084
Margin of Safety	40	826	908,000	0.31	7.11	6,676
Total Load	417	9,668	9,080,000	3.07	71.08	66,760

Table 6- Annual and daily load allocations for Eureka City Lake. Daily allocations calculated following guidance regarding Anacostia decision. Daily load calculations included in Appendix C.

State Water Plan Implementation Priority: Because this water may be a public drinking water supply source in the future, the Eureka City Lake TMDL will be a **Medium Priority** for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Upper Verdigris Watershed (HUC 8: 11070101) with a priority ranking of 58 (Low Priority for restoration).

Priority Areas: Implementation of land use practices should be targeted to those areas within 300 feet of Bachelor Creek and in the near-shore area around the lake. Implementation of sanitary waste system operational improvements should be targeted to residences around the lake.

5. IMPLEMENTATION

Desired Implementation Activities

Implementation should proceed with a focus on adaptive management. Initial areas of focus include identification of areas where unstable streambanks may be contributing to sediment and nutrient loading, detection and elimination of concentrated manure, alternative watering sites or livestock exclusion from streams and ponds, and detection and elimination of failing sanitary waste systems in the watershed. As time proceeds tracking the success of implementation measures should guide future implementation efforts to management practices showing the greatest reduction in loading.

There is a good potential for reducing pollutant loads to this lake through the use of best management practices. Some of the recommended practices are as follows:

1. Reduce activities within riparian areas.
2. Provide alternate water sources for livestock, and fence stream channels.
3. Conduct outreach to ensure the proper functioning of sanitary waste systems at lake residences.

Implementation Programs Guidance

Non-Point Source Pollution Technical Assistance - KDHE

a. Support Section 319 demonstration projects for reduction of siltation runoff from agricultural or road construction activities

b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.

c. Provide technical assistance on road construction activities in vicinity of streams.

d. Support the development, assessment, planning and implementation of a developing WRAPS to comprehensively reduce the loading and delivery of pesticides, sediment and nutrients to the stream system throughout its watershed.

Water Resource Cost Share & Non-Point Source Pollution Control Programs - SCC

a. Provide sediment control practices to minimize erosion and sediment transport

Riparian Protection Program - SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.

b. Develop riparian restoration projects

Extension Outreach and Technical Assistance - Kansas State University

a. Educate agricultural producers on sediment and pasture management

b. Provide technical assistance on buffer strip design and minimizing cropland runoff

Time Frame for Implementation: Exclusion of cattle from within a 300 foot buffer along Bachelor Creek should occur through 2013. Inspection of on-site wastewater systems should occur before 2013. Repair, replacement or retirement of failing systems should occur concurrently with inspections. During 2008-2013 monitoring of in-lake conditions shall continue and show improved levels of ambient TP and chlorophyll a.

Delivery Agents: The primary delivery agents for program participation will be the Greenwood County Conservation District for programs of the State Conservation Commission and the Natural Resources Conservation Service. Producer outreach and awareness will be delivered by Kansas State Extension. The Kansas Department of Health and Environment shall continue to monitor lake conditions.

Targeted Participants: Primary participants for implementation of best management practices will be agricultural producers and lakeside residence owners within the drainage of the lake and the City of Eureka.

Milestone for 2013: The year 2013 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from Eureka City Lake will be reexamined to confirm the impaired status of the lake. Should impairment remain, more aggressive techniques will be examined to remove potential sources of sediment and nutrients from the lake.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

6. The *Kansas Water Plan* and the Verdigris Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the

Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL is a **Medium Priority** consideration. Priority should be given to activities which reduce loadings of phosphorus and nitrogen to the lake prior to 2013.

Effectiveness: Phosphorus and nitrogen reduction has proven effective at reducing chlorophyll concentrations in a wide range of lakes worldwide.

6. MONITORING

Further sampling should occur before 2013. The Kansas Department of Health and Environment is planning to survey the lake in 2008 and 2011.

7. FEEDBACK

Public Meetings: Public Meetings to discuss TMDLs in the Verdigris Basin have been held since 2002. An active Internet Web site was established at http://www.kdheks.gov/tmdl/index.htm to convey information to the public on the general establishment of TMDLs in the Verdigris Basin and these specific TMDLs.

Public Hearing: A Public Hearing on these Verdigris Basin TMDLs was held in Neodesha on July 23, 2008.

Basin Advisory Committee: The Verdigris Basin Advisory Committee met to discuss these TMDLs on September 25, 2007 in Eureka and July 23, 2008 in Neodesha.

Milestone Evaluation: In 2013, evaluation will be made as to implementation of management practices to minimize the nonpoint source runoff contributing to this impairment. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2013 with consultation from the Verdigris Basin WRAPS teams.

Consideration for 303d Delisting: Eureka City Lake will be evaluated for delisting under Section 303d, based on the monitoring data over 2008-2015. Therefore, the decision for delisting will come about in the preparation of the 2016-303d list. Should modifications be made to the applicable water quality criteria during the implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities might be adjusted accordingly.

Incorporation into Continuing Planning Process, Water Quality, Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision would come in 2008, which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made into the WRAPS. Recommendations of this TMDL will be considered in the *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2008-2015.

TMDL# VE022-102-EU2-40201-008
Developed November 24, 2008

Appendix A- Model Input and Mass Balance

BATHTUB model input for current conditions

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.889	0.0
Evaporation (m)	1.3081	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	10	0.10
Total N	665	0.14
Ortho P	10	0.10
Inorganic N	665	0.14

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	1	2ND ORDER, AVAIL N
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segname 1	0	1	0.963	3.62	1.6	3.5	0	6	0	0.75	0.5	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	39	0.5	535	0.5	17.8	0.5	0.838	0.5	443	0.5	20	0.5	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Inflow	1	1	40	7.49	0	0	0	45	0	1088	0	20	0	544	0
2	SepticSystems	1	1	0.1	0.004866	0	0	0	10000	0	35000	0	5000	0	17500	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	0.500	0.45
Total Nitrogen	2.150	0.55
Chl-a Model	1.470	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

BATHTUB model input for needed load reductions

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.889	0.0
Evaporation (m)	1.3081	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	10	0.10
Total N	665	0.14
Ortho P	10	0.10
Inorganic N	665	0.14

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	1	2ND ORDER, AVAIL N
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segname 1	0	1	0.963	3.62	1.6	3.5	0	6	0	0.75	0.5	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	39	0.5	535	0.5	17.8	0.5	0.838	0.5	443	0.5	20	0.5	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Inflow	1	1	40	7.49	0	0	0	24	0	500	0	10	0	250	0
2	SepticSystems	1	1	0.1	0.004866	0	0	0	1	0	1	0	1	0	1	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	0.500	0.45
Total Nitrogen	2.150	0.55
Chl-a Model	1.470	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

BATHTUB model mass balance for current conditions

Overall Mass Balance Based Upon Component:				**Predicted TOTAL P Load**		**Outflow & Reservoir Concentrations Load Variance**			**Conc**	**Export**	Load
Trb	**Type**	**Seg**	**Name**	**kg/yr**	**%Total**	**$(kg/yr)^2$**	**%Total**	**CV**	**mg/m^3**	**$kg/km^2/yr$**	**lbs/year**
1	1	1	Inflow	337.0	85.3%	0.00E+00		0.00	45.0	8.4	743.0671
2	1	1	SepticSystems	48.7	12.3%	0.00E+00		0.00	10000.0	486.6	107.2768
PRECIPITATION				9.6	2.4%	9.27E-01	100.0%	0.10	11.2	10.0	21.23049
TRIBUTARY INFLOW				385.7	97.6%	0.00E+00		0.00	51.5	9.6	850.344
***TOTAL INFLOW				395.3	100.0%	9.27E-01	100.0%	0.00	47.3	9.6	871.5745
ADVECTIVE OUTFLOW				256.8	65.0%	8.76E+02		0.12	36.2	6.3	566.2109
***TOTAL OUTFLOW				256.8	65.0%	8.76E+02		0.12	36.2	6.3	566.2109
***RETENTION				138.5	35.0%	8.76E+02		0.21			305.3636

Overflow Rate (m/yr)	7.4	Nutrient Resid. Time (yrs)	0.3194
Hydraulic Resid. Time (yrs)	0.4916	Turnover Ratio	3.1
Reservoir Conc (mg/m3)	36	Retention Coef.	0.350

Overall Mass Balance Based Upon Component:				**Predicted TOTAL N Load**		**Outflow & Reservoir Concentrations Load Variance**			**Conc**	**Export**	
Trb	**Type**	**Seg**	**Name**	**kg/yr**	**%Total**	**$(kg/yr)^2$**	**%Total**	**CV**	**mg/m^3**	**$kg/km^2/yr$**	
1	1	1	Inflow	8149.1	91.0%	0.00E+00		0.00	1088.0	203.7	17965.71
2	1	1	SepticSystems	170.3	1.9%	0.00E+00		0.00	35000.0	1703.1	375.4688
PRECIPITATION				640.4	7.1%	8.04E+03	100.0%	0.14	748.0	665.0	1411.828
TRIBUTARY INFLOW				8319.4	92.9%	0.00E+00		0.00	1110.0	207.5	18341.18
***TOTAL INFLOW				8959.8	100.0%	8.04E+03	100.0%	0.01	1072.9	218.2	19753.01
ADVECTIVE OUTFLOW				3873.0	43.2%	5.75E+05		0.20	546.2	94.3	8538.415
***TOTAL OUTFLOW				3873.0	43.2%	5.75E+05		0.20	546.2	94.3	8538.415
***RETENTION				5086.9	56.8%	5.79E+05		0.15			

Overflow Rate (m/yr)	7.4	Nutrient Resid. Time (yrs)	0.2125
Hydraulic Resid. Time (yrs)	0.4916	Turnover Ratio	4.7
Reservoir Conc (mg/m3)	546	Retention Coef.	0.568

BATHTUB model mass balance for needed load reductions

Overall Mass Balance Based Upon Component: **Predicted TOTAL P** **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$	Load lbs/year
1	1	1	Inflow	179.8	94.9%	0.00E+00		0.00	24.0	4.5	396.3025
2	1	1	SepticSystems	0.0	0.0%	0.00E+00		0.00	1.0	0.0	0.010728
PRECIPITATION				9.6	5.1%	9.27E-01	100.0%	0.10	11.2	10.0	21.23049
TRIBUTARY INFLOW				179.8	94.9%	0.00E+00		0.00	24.0	4.5	396.3132
***TOTAL INFLOW				189.4	100.0%	9.27E-01	100.0%	0.01	22.7	4.6	417.5437
ADVECTIVE OUTFLOW				145.2	76.6%	1.50E+02		0.08	20.5	3.5	320.0054
***TOTAL OUTFLOW				145.2	76.6%	1.50E+02		0.08	20.5	3.5	320.0054
***RETENTION				44.2	23.4%	1.50E+02		0.28			97.53832

Overflow Rate (m/yr)	7.4	Nutrient Resid. Time (yrs)	0.3768
Hydraulic Resid. Time (yrs)	0.4916	Turnover Ratio	2.7
Reservoir Conc (mg/m3)	20	Retention Coef.	0.234

Overall Mass Balance Based Upon Component: **Predicted TOTAL N** **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$	
1	1	1	Inflow	3745.0	85.4%	0.00E+00		0.00	500.0	93.6	8256.302
2	1	1	SepticSystems	0.0	0.0%	0.00E+00		0.00	1.0	0.0	0.010728
PRECIPITATION				640.4	14.6%	8.04E+03	100.0%	0.14	748.0	665.0	1411.828
TRIBUTARY INFLOW				3745.0	85.4%	0.00E+00		0.00	499.7	93.4	8256.313
***TOTAL INFLOW				4385.4	100.0%	8.04E+03	100.0%	0.02	525.1	106.8	9668.14
ADVECTIVE OUTFLOW				2412.2	55.0%	1.65E+05		0.17	340.2	58.7	5317.915
***TOTAL OUTFLOW				2412.2	55.0%	1.65E+05		0.17	340.2	58.7	5317.915
***RETENTION				1973.2	45.0%	1.67E+05		0.21			

Overflow Rate (m/yr)	7.4	Nutrient Resid. Time (yrs)	0.2704
Hydraulic Resid. Time (yrs)	0.4916	Turnover Ratio	3.7
Reservoir Conc (mg/m3)	340	Retention Coef.	0.450

Appendix B- Reduction Model Output

PREDICTED CONCENTRATIONS:

Variable Segment-->	1
TOTAL P MG/M3	20.0
TOTAL N MG/M3	334.0
C.NUTRIENT MG/M3	12.2
CHL-A MG/M3	9.8
SECCHI M	1.0
ORGANIC N MG/M3	437.8
TP-ORTHO-P MG/M3	31.2
HOD-V MG/M3-DAY	125.5
MOD-V MG/M3-DAY	99.1
ANTILOG PC-1	134.9
ANTILOG PC-2	7.8
(N - 150) / P	9.2
INORGANIC N / P	1.0
TURBIDITY 1/M	0.8
ZMIX * TURBIDITY	2.6
ZMIX / SECCHI	3.5
CHL-A * SECCHI	9.9
CHL-A / TOTAL P	0.5
FREQ(CHL-a>10) %	36.8
FREQ(CHL-a>20) %	7.3
FREQ(CHL-a>30) %	1.8
FREQ(CHL-a>40) %	0.5
FREQ(CHL-a>50) %	0.2
FREQ(CHL-a>60) %	0.1
CARLSON TSI-P	47.3
CARLSON TSI-CHLA	53.0
CARLSON TSI-SEC	59.9

Appendix C– Conversion to Daily Loads as Regulated by EPA Region VII

The TMDL has estimated annual average loads for TP that if achieved should meet the water quality targets. A recent court decision often referred to as the "Anacostia decision" has dictated that TMDLs include a "daily" load (Friend of the Earth, Inc v. EPA, et al.).

Expressing this TMDL in daily time steps could be misleading to imply a daily response to a daily load. It is important to recognize that the growing season mean chlorophyll *a* is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load and algal response.

To translate long term averages to maximum daily load values, EPA Region 7 has suggested the approach describe in the Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001)(TSD).

Maximum Daily Load (MDL) = (Long-Term Average Load) * $e^{[Z\sigma - 0.5\sigma^2]}$

where $\sigma^2 = \ln\left(CV^2 + 1\right)$

CV = Coefficient of variation = Standard Deviation / Mean

Z = 2.326 for 99th percentile probability basis

LTA= Long Term Average

LA= Load Allocation

MOS= Margin of Safety

Parameter	LTA-lbs/year	CV	e[Zδ-0.5δ^2]	MDL- lbs/day	LA- lbs/day	MOS (10%)- lbs/day
TP	417	0.5	2.68367144	3.066002708	2.75940244	0.306600271
TN	9668	0.5	2.68367144	71.08420667	63.975786	7.108420667
Sediment	9080000	0.5	2.68367144	66760.92228	60084.8301	6676.092228

Maximum Daily Load Calculation

Maximum Daily Load = (Long-Term Average Load) * e $^{[Z\sigma - 0.5\sigma^2]}$

where $\sigma^2 = \ln(CV^2 + 1)$

CV = Coefficient of variation (0.5)

Z = 2.326 for 99th percentile probability basis

Annual TP Load = 417 lbs/yr

Maximum Daily TP Load = [(417 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 3.06 lbs/day

Margin of Safety (MOS) for Daily Load

Annual TP MOS = 40 lbs/yr

Daily TP MOS = [(40 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 0.294 lbs/day

Maximum Daily Load Calculation

Maximum Daily Load = (Long-Term Average Load) * e $^{[Z\sigma - 0.5\sigma^2]}$

where $\sigma^2 = \ln(CV^2 + 1)$

CV = Coefficient of variation (0.5)

Z = 2.326 for 99th percentile probability basis

Annual TN Load = 9,668 lbs/yr

Maximum Daily TN Load = [(9,668 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 71 lbs/day

Margin of Safety (MOS) for Daily Load

Annual TN MOS = 826 lbs/yr

Daily TN MOS = [(826 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 6.07 lbs/day

Maximum Daily Load Calculation

Maximum Daily Load = (Long-Term Average Load) * e $^{[Z\sigma - 0.5\sigma^2]}$

where $\sigma^2 = \ln\left(CV^2 + 1\right)$

CV = Coefficient of variation (0.5)

Z = 2.326 for 99th percentile probability basis

Annual Sediment Load = 9,080,000 lbs/yr

Maximum Daily TP Load = [(9,080,000 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 66,761 lbs/day

Margin of Safety (MOS) for Daily Load

Annual Sediment MOS = 908,000 lbs/yr

Daily Sediment MOS = [(908,000 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 6,676 lbs/day

Source- *Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001)*

Appendix D- Model Calibration and Input Data Sources

Universal Data-

All lake water quality data is the numeric average of all data collected by KDHE in the epilimnion of the lake. CV arbitrarily assigned to 0.5.

Precipitation data is from the PRISM group average values for precipitation from 1971-2000. http://www.prism.oregonstate.edu/index.phtml

Evaporation data from USGS Hydrological Estimates for Kansas Lakes.

Atmospheric loads of TP, TN, Ortho-P and DIN are BATHTUB default values.

Model Options are all BATHTUB default options.

Lake morphometry data calculated from KBS bathymetry data using ArcGIS 9.2.

Mixed layer depth is the average depth as measured by KDHE during lake sampling events.

Non-algal turbidity calculated by BATHTUB.

Lake segment calibration factors are all BATHTUB defaults.

Drainage area calculated using ArcGIS 9.2.

Flow estimates for inflow from USGS Hydological Estimates for Kansas Lakes.

Model Coefficients were adjusted to calibrate model results to specific observed conditions in Eureka City Lake. Total phosphorus, total nitrogen and chl-a were adjusted within ranges recommended in EPA Region 7 sponsored training on BATHTUB model development by Tetra-Tech. Models coefficients were considered acceptable when t-test statistics were no longer significant at an alpha of 0.05.

Current Conditions Tributary Data-

Inflow-

Total phosphorus inflow concentration estimated based on measured data from Fall River Lake. Concentrations were adjusted by watershed size to better approximate the likely conditions in the inflowing streams. Annual load estimates per unit area were divided into the total annual estimated inflow to determine average concentration for model development.

Total nitrogen inflow concentration estimated based on measured data from Fall River Lake. Model results suggested that no adjustment for watershed size was needed for this parameter. Annual load estimates per unit area were divided into the total annual estimated inflow to determine average concentration for model development.

Ortho-p assigned to KDHE practical quantitation limit.

DIN assign a value of half of total nitrogen concentration.

Septic Systems-

Houses were assumed to have 2.5 people, based on national average data. STEPL models assume 2.43 people per household as a default value. EPA Publication 625/R-00/008 *Onsite Watewater Treatment Systems Manual* describes a national average of 2.7 people per household.

Per person contributions to septic flows were assigned 45 gallons per person per day, following EPA publication 625/1-80-012 *Design Manual Onsite Wastewater Treatment and Disposal Systems* (pg. 51).

Population estimate of year round residents was calculated from selection of 2000 US Census data blocks adjacent to the lake.

Calculation of total lakeshore houses was conducted through visual evaluation of 2002 DOQQ 1 meter resolution aerial photographs.

Estimates of seasonally used homes calculated by subtraction of estimated year round houses (2000 Census population/national average people per household) subtracted from total lakeshore households.

Estimates of seasonal use levels were based on best professional judgment. Seasonally used households were assumed to use lakeshore residences 55 days per year, or about every other weekend and occasional holidays. Estimates of use at seasonal residence assumed an average household of four people and two guests, for six people using the house 55 days per year at average wastewater flow rates.

Nutrient concentrations in failing septic systems were assigned based on estimates from Novotony & Olem (1994) as cited in EPA publication 841-B-99-007, *Protocol for Developing Nutrient TMDLs*. Inorganic nitrogen and ortho-P were assigned half the total value for these parameters.

Based on national average data, and Kansas average data, estimates of percentage of failing septic systems was assigned to 50%. This is approximately triple overall averages (EPA Publication 600/R-00/008, *BIOCHLOR: Natural Attentuation Decision Support System: Users Manual,* Table 1-3), to account for likely lower maintenance associated with seasonal use houses and the overall age of the lake. This failure rate is consistent with failure rates observed in Minnesota, Missouri & West Virginia.

Average annual failing septic system flows were calculated by multiplication of average flow values by the total number of person-days estimated at all lake residences combined.

Load Reduction Condition Tributary Data-
Septic Systems-
To avoid alteration to hydraulic parameters, annual flow from septic systems was left at current conditions rate. Septic flows were estimated to contribute only 0.065% of total annual flows. Nutrient concentrations were assigned 1 ppb to avoid BATHTUB model errors associated with zero values in inflow concentration estimates. Effectively this reduction is a complete elimination of failing septic systems.

Inflow-
Nutrient concentrations were adjusted in a pair-wise TP/TN concurrent reduction scheme and the model was re-run until acceptable chlorophyll concentrations were obtained. Inorganic nitrogen and ortho-P were reduced concurrently and at approximately the same rate as a percentage of total concentration.

Appendix E- STEPL Watershed Load Model

STEPL Input Sheet: Values in RED are required input. Change worksheets by clicking on tabs at the bottom. You entered 1 subwatershed(s).

This sheet is composed of eight input tables. The first four tables require users to change initial values. The next four tables (initially hidden) contain default values users may choose to change.
Step 1: Select the state and county where your watersheds are located. Select a nearby weather station. This will automatically specify values for rainfall parameters in Table 1 and USLE parameters in Table 4.
Step 2: (a) Enter land use areas in acres in Table 1; (b) enter total number of agricultural animals by type and number of months per year that manure is applied to croplands in Table 2;
(c) enter values for septic system parameters in Table 3; and (d) if desired, modify USLE parameters associated with the selected county in Table 4.
Step 3: You may stop here and proceed to the BMPs sheet. If you have more detailed information on your watersheds, click the Yes button in row 10 to display optional input tables.
Step 4: (a) Specify the representative Soil Hydrologic Group (SHG) and soil nutrient concentrations in Table 5; (b) modify the curve number table by landuse and SHG in Table 6;
(c) modify the nutrient concentrations (mg/L) in runoff in Table 7; and (d) specify the detailed land use distribution in the urban area in Table 8.
Step 5: Select BMPs in BMPs sheet. **Step 6**: View the estimates of loads and load reductions in Total Load and Graphs sheets.

Show optional input tables? Yes No ☐ Treat all the subwatersheds as parts of a single watershed ☐ Groundwater load calculation

State: Kansas
County:
Weather Station (for rain correction factors): KS FALL RIVER LAKE

1. Input watershed land use area (ac) and precipitation (in)

Rain correction factors: 0.886, 0.498

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total	Annual Rainfall	Rain Days	Avg. Rain/Event
W1	0	27	9058	140	313	0	0-24%	9538	35.01	83	0.750

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	# of months manure applied
W1	1213	0	0	0	0	0	0	0	0
Total	1213	0	0	0	0	0	0	0	

3. Input septic system and illegal direct wastewater discharge data

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %	Wastewater Direct Discharge, # of People	Direct Discharge Reduction, %
W1	69	2.43	50	0	0

4. Modify the Universal Soil Loss Equation (USLE) parameters

Watershed	Cropland					Pastureland					Forest					User Defined				
	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P
W1	150.000	0.260	0.193	0.244	0.993	150.000	0.260	0.568	0.020	1.000	150.000	0.260	0.193	0.003	1.000	150.000	0.260	0.193	0.020	1.000

Optional Data Input:

5. Select average soil hydrologic group (SHG), SHG A = highest infiltration and SHG D = lowest infiltration

Watershed	SHG A	SHG B	SHG C	SHG D	SHG Selected	Soil N conc.%	Soil P conc.%	Soil BOD conc.%
W1	◉	○	○	○	A	0.050	0.010	0.100

6. Reference runoff curve number (may be modified)

SHG	A	B	C	D
Urban	83	89	92	93
Cropland	67	78	85	89
Pastureland	30	69	79	84
Forest	30	60	73	79
User Defined	50	70	80	85

6a. Detailed urban reference runoff curve number (may be modified)

Urban\SHG	A	B	C	D
Commercial	89	92	94	95
Industrial	81	88	91	93
Institutional	81	88	91	93
Transportation	98	98	98	98
Multi-Family	77	85	90	92
Single-Family	57	72	81	86
Urban-Cultivat	67	78	85	89
Vacant-Develo	77	85	90	92
Open Space	49	69	79	84

7. Nutrient concentration in runoff (mg/l)

Land use	N	P	BOD
1. L-Cropland	**1.9**	**0.3**	**4**
1a. w/ manure	8.1	2	12.3
2. M-Cropland	**2.9**	**0.4**	**6.1**
2a. w/ manure	12.2	3	18.5
3. H-Cropland	**4.4**	**0.5**	**9.2**
3a. w/ manure	18.3	4	24.6
4. Pasturelan	**5**	**0.1**	**13**
5. Forest	**0.2**	**0.02**	**0.5**
6. User Defin	**0**	**0**	**0**

7a. Nutrient concentration in shallow groundwater (mg/l) (may be modified)

Landuse	N	P	BOD
Urban	1	0.01	0
Cropland	1.44	0.063	0
Pastureland	1.44	0.005	0
Forest	0.11	0.005	0
Feedlot	6	0.07	0
User-Defined	0	0	0

8. Input or modify urban land use distribution

Watershed	Urban Area (ac.)	Commercial %	Industrial %	Institutional %	Transportation %	Multi-Family %	Single-Family %	Urban-Cultivated %	Vacant (developed)	Open Space %	Total % Area
W1	0	0	0	0	0	0	0	0	0	100	100

9. Input irrigation area (ac) and irrigation amount (in)

Watershed	Total Cropland (ac)	Cropland: Acres Irrigated	Water Depth (in) per Irrigation - Before BMP	Water Depth (in) per Irrigation - After BMP	Irrigation Frequency (#/Year)
W1	27	0	0	0	0

Input Ends Here.

Total Load	This is the summary of annual nutrient and sediment load for each subwatershed. This sheet is initially protected.

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)	%N Reduction	%P Reduction	%BOD Reduction	%Sed Reduction
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	%	%	%	%
W1	17639.4	1262.4	45722.8	1379.4	0.0	0.0	0.0	0.0	17639.4	1262.4	45722.8	1379.4	0.0	0.0	0.0	0.0
Total	17639.4	1262.4	45722.8	1379.4	0.0	0.0	0.0	0.0	17639.4	1262.4	45722.8	1379.4	0.0	0.0	0.0	0.0

2. Total load by land uses (with BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	0.00	0.00	0.00	0.00
Cropland	225.22	32.42	463.74	39.51
Pastureland	16234.97	789.37	40662.01	1290.76
Forest	14.61	2.08	33.45	3.09
Feedlots	0.00	0.00	0.00	0.00
User Defined	92.01	18.40	184.03	46.01
Septic	1072.54	420.08	4379.55	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00
Total	17639.36	1262.35	45722.77	1379.36